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Depth dependent optical and elasto-optical effects of ion implantation studied by time-domain Brillouin scattering

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In semiconductors, defects (vacancies, interstitials) and dopants play a critical role in the performance of electrical devices. Such defects become increasingly important as size scales approach the order of tens of nanometers and the influence of defects may significantly alter the entire device performance. Under these circumstances it is extremely important to identify both the location and concentration of defects as well as their effect on the optoelectronic properties. Traditionally, either optical or ion beam analysis methods have been used to characterize defect distributions. On one hand, while optical methods can deliver information regarding the average electronic structure, depth-dependent information is typically lost in measurement. Ion beam analysis, while providing some depth resolution, creates damage in a sample similar to that which is being studied and, in general, is not sensitive on dopant fluences lower than 10^{16} cm^{-2}.

In this talk, results of time-domain Brillouin scattering from implanted samples will be discussed. We have applied TDBS, also known as coherent acoustic phonon spectroscopy or picosecond ultrasonics, to the characterization of implanted GaAs [1], diamond [2], silicon carbide [3], and GaP specimens. The changes of the optoelectronic properties (refractive index, extinction coefficient, photoelastic coefficients) of these materials as a function of depth as well as defect concentration have been determined.

An ultrafast laser pulse (120 fs) was employed to generate and monitor a picosecond strain wave which transiently modifies the material as it passes through the specimen. The resulting time-resolved optical response is highly sensitive to local changes in a material's photoelastic properties. Our measurements extend over two orders of magnitude in defect concentration, and provide a tabletop method for non-invasive and non-destructive defect characterization, which is two orders of magnitude more sensitive than channeling.

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References

[1] A. Baydin, H. Krzyzanowska, R. Gatamov, J. Garnett, and N. Tolk, Sci. Rep. 7, 15150 (2017)
[2] J. Gregory, A. Steigerwald, H. Takahasi, A. Hmelo, and N. Tolk, Applied Physics Letters 101, 181904 (2012)
[3] A. Baydin, H. Krzyzanowska, M. Dhanunjaya, SVS Nageswara Rao, J.L Davidson, L.C. Feldman, N.H. Tolk, Appl. Phys. Lett. Photonics, 1, 036102 (2016)